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Special Publication No. 1

ON FISHERY FOR "IWASHI" (SARDINE, ANCHOVY AND ROUND HERRING) AND RESEARCH OF ITS RESOURCES IN THE JAPANESE WATERS

by Zinziro Nakai

October, 1952

Tokyo

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Sardine Resources Division

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E R R A T A

age	Line	Error	Correction
3	1	a 1929-42	a 1914-28
3	45	take place in the spring	takes place in the spring
6	14	in spect of	in respect of
6	41	the sh ltered bays	the sheltered bays
6	49	a depth of 150 .	a depth of 150 m.
11	10	the age of the V age fish	the age determination of the V age fish
11	23	among the yound	among the young
12	3	the aultimate purpose	the ultimate purpose
12	12	the research work covers	the research work cover
12	43	has been employed	have been employed

ON FISHERY FOR "IWASHI" (SARDINE, ANCHOVY AND ROUND HERRING) AND RESEARCH OF ITS RESOURCES IN THE JAPANESE WATERS

INTRODUCTION

"Iwashi" is the general name applied in Japanese fishing industry to three species of the fish of which specific name are as follows:

Japanese Name	English Name	Scientific Name
"Maiwashi"	Sardine	Sardinia melanosticta (T. & S.)
"Katakuchi Iwashi"	Anchovy	Englauris japonicus T. & S.
"Urume Iwashi"	Round Herring	Etrumeus micropus (T. & S.)

According to the Statistical Yearbook published by Ministry of Agriculture and Forestry, the annual total of fish landings averaged approximately 2,670,000 metric tons for a 1929-38 period, excluding shellfish, seaweed and other aquatic products than fish.

Of this figure the catch of "iwashi" amounted about 1,200,000 tons, or 45 percent of the total, on the average for the same period. The catch in the recent years was suffered such serious depletion that an annual average for a 1941-50 period remained about 550,000 tons. Even in that period, however, "iwashi" continued to be in a dominant position among other fish as the amount stated above represents 28 percent of the total landings of fish. The fact may justify that "iwashi" is regarded to be the most important fish as food, particularly a source of animal protein, for Japanese population, and also from an economical point of view.

Such importance of the fish and remarkable fluctuation of the catch as mentioned above are the reasons which made it necessary to conduct scientific research on the stock of "iwashi" with a special emphasis placed upon it from various quarters of post-war Japan. With this view in mind the research has been carried out on a national-wide scale since 1949.

OUTLINE OF "IWASHI" FISHERY

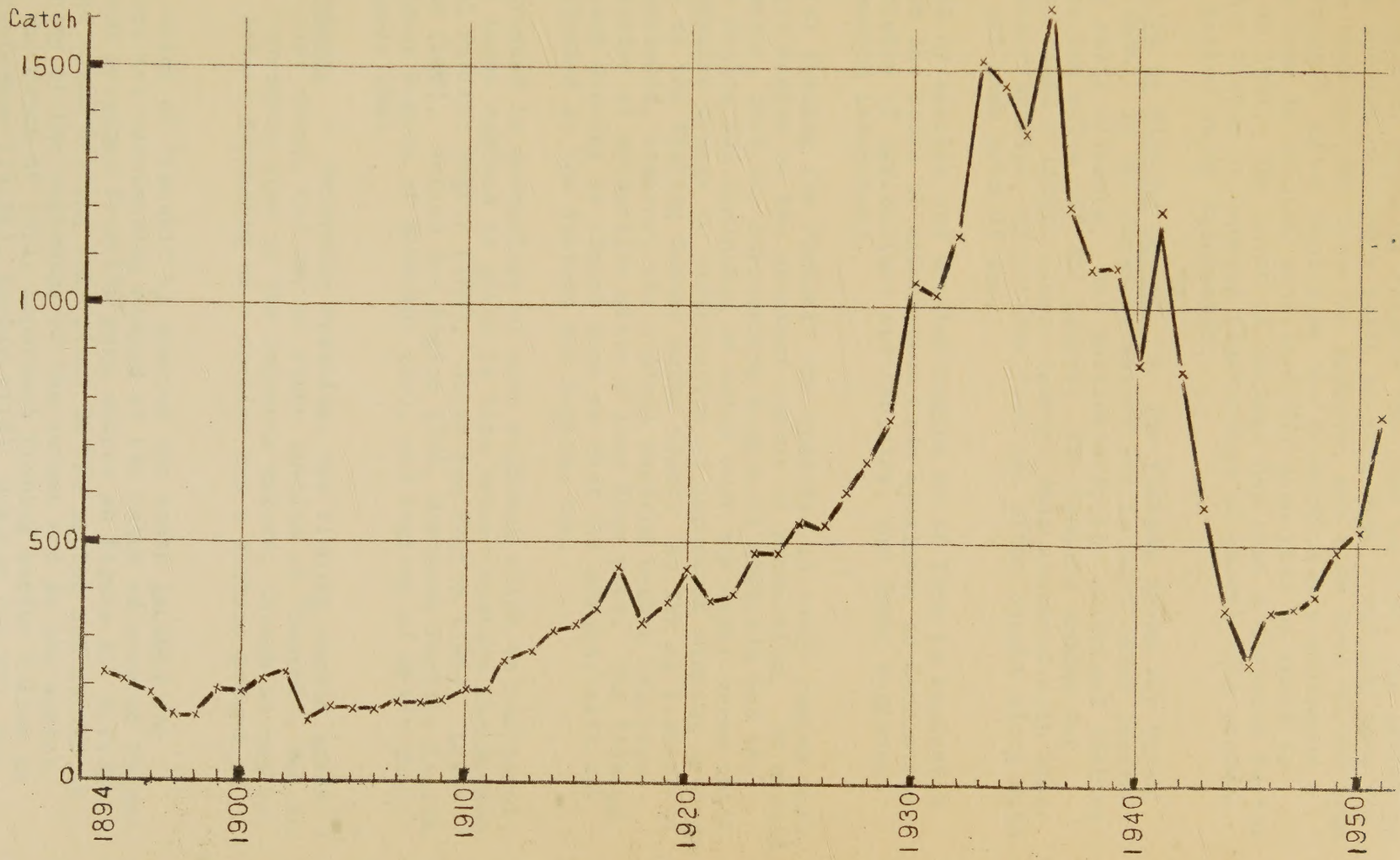
1. Fluctuation in Annual Catch. - Although no information has been made available for a historical background of "iwashi" fishery in Japan as to when it started to operate on a commercial scale, a fragmental records show that around 1487 the fish were caught by beach seines at various localities. Since then up to present, the fishery for this fish seems to have been carried on with turn of the catch, favorable in some year but adverse in others.

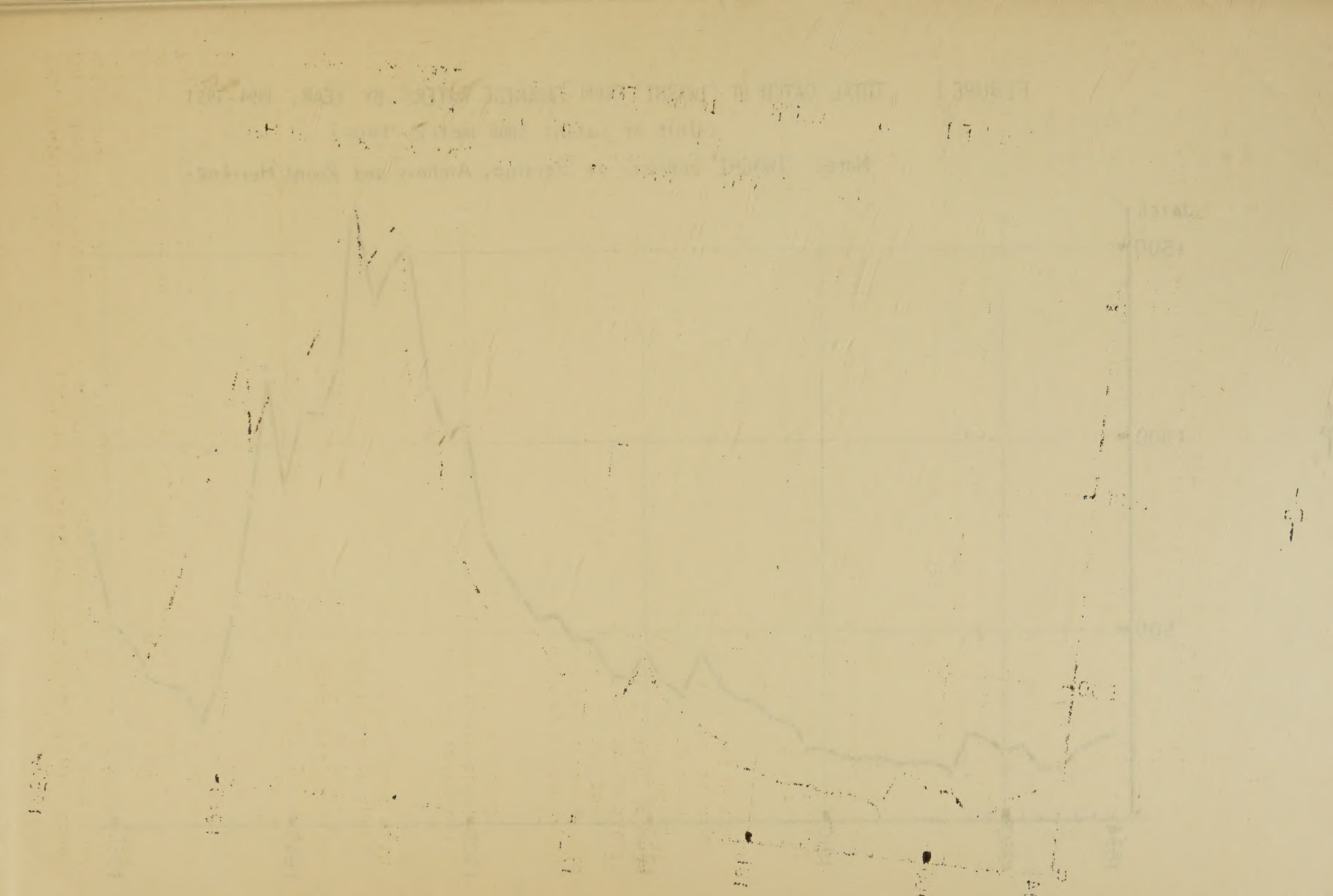
Statistical records of the commercial catch throughout the country have been provided on a census system since 1894 by a governmental agency then called Ministry of Agriculture and Commerce, and published in the form of yearbook together with other statistics. Figure 1 shows the annual catch of "iwashi" for a period 1894 to 1951 on the basis of data derived from those statistics. As you see, the catch is on the increase with such great strides as 100,000-300,000 metric tons up to 1913,

FIGURE 1 TOTAL CATCH OF "IWASHI" FROM JAPANESE WATERS BY YEAR, 1894–1951

(Unit of Catch: 1,000 metric tons)

Note: "IWASHI" consists of Sardine, Anchovy and Round Herring.





300,000-700,000 tons for a 1929-42 period, and 800,000-1,630,000 tons for a 1929-42 period, until it reaches the peak in 1936. (An estimated break-down by species of 1936's catch is more than 1,460,000 tons for sardine, less than 120,000 tons for anchovy, and less than 50,000 tons for round herring.) After that year the production has undergone a sheer decline down to 260,000 tons in 1945, then rose up again to 760,000 tons in 1951. The catch of sardine has been a decesive factor more than other fishes in causing fluctuation of annual fish production for the period under discussion.

2. Distribution of Fishing Ground. - The fishing areas for three species of "iwashi" in the Japanese waters are in most cases located within twenty miles offshore, and particularly the principal fishing grounds within ten miles off the coasts. The fishing ground for anchovy may be found a little closer inshore when compared with those for the two other species, as yet the fish are often caught along with sardine from the same area of sea.

The catch by species and coastal region as of 1951 is indicated on Figure 2 on the basis of information made available to Statistics Division, Ministry of Agriculture and Forestry, and Tokai Regional Fisheries Research Laboratory.

Commercial fishing for "iwashi" are operated in every region with the Western Sea Region as the greatest center of production. It should be noted, however, that the Surrounding Region of Hokkaido and the Upper Pacific Region had dominated in catch over the other areas until 1941. A remarkable change in distribution of important fishing grounds occurred just as the fishing became quite slack. As far as fishing of anchovy is concerned, however, the Central Pacific Region has been the largest center of production since a long time past. The fishing ground for round herring is almost same as that for sardine with the major area situated in the Western Sea Region, too.

When expressed in percentage of each regional catch to the total, importance of these regions is given in this order: Western Sea Region (40%), Central Pacific Region (17%), Japan Sea Region (14%), Lower Pacific Region (10%), Inland Sea Region (7%), Northern Pacific Region (2%), Surrounding Region of Hokkaido (2%), and regions of which names are not available (8%).

3. Fishing Season. - Generally speaking, the fishing season takes place all the year round, for one or other species of "iwashi", and in one region or somewhere else in the Japanese waters, though it may be classified in detail depending on a species and a fishing ground in particular.

Take the catch of "iwashi" by species and month in 1951 for instance. There are outstanding ridges of the catch as seen on Figure 3 which has been prepared from the same source as Figure 2. A ridge for sardine and round herring take place in the spring and autumn, a ridge for anchovy at the beginning of the autumn and in the winter. When based on the catch of 1951, important fishing months follow in this order; September (14.5%), August (11%), October (10.7%), May (10.3%), December (9.7%), November (9.6%), July (9.2%), June (6.4%), January (5.4%), April (4.8%), March (4.2%), and February (3.9%).

FIGURE 2 AMOUNT OF CATCH BY SPECIES AND REGION, 1951
(Unit of Catch: 1,000 metric tons)

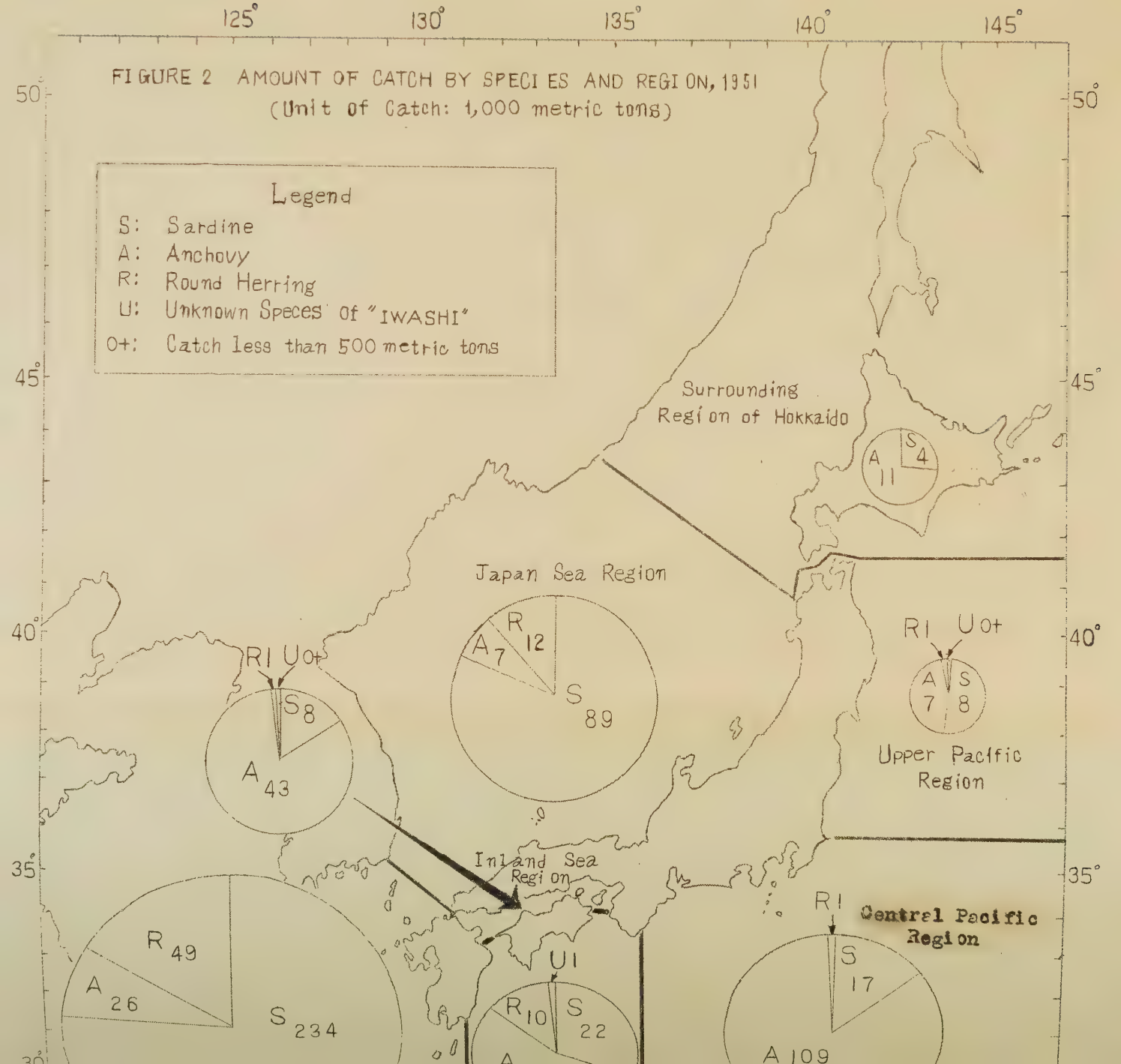
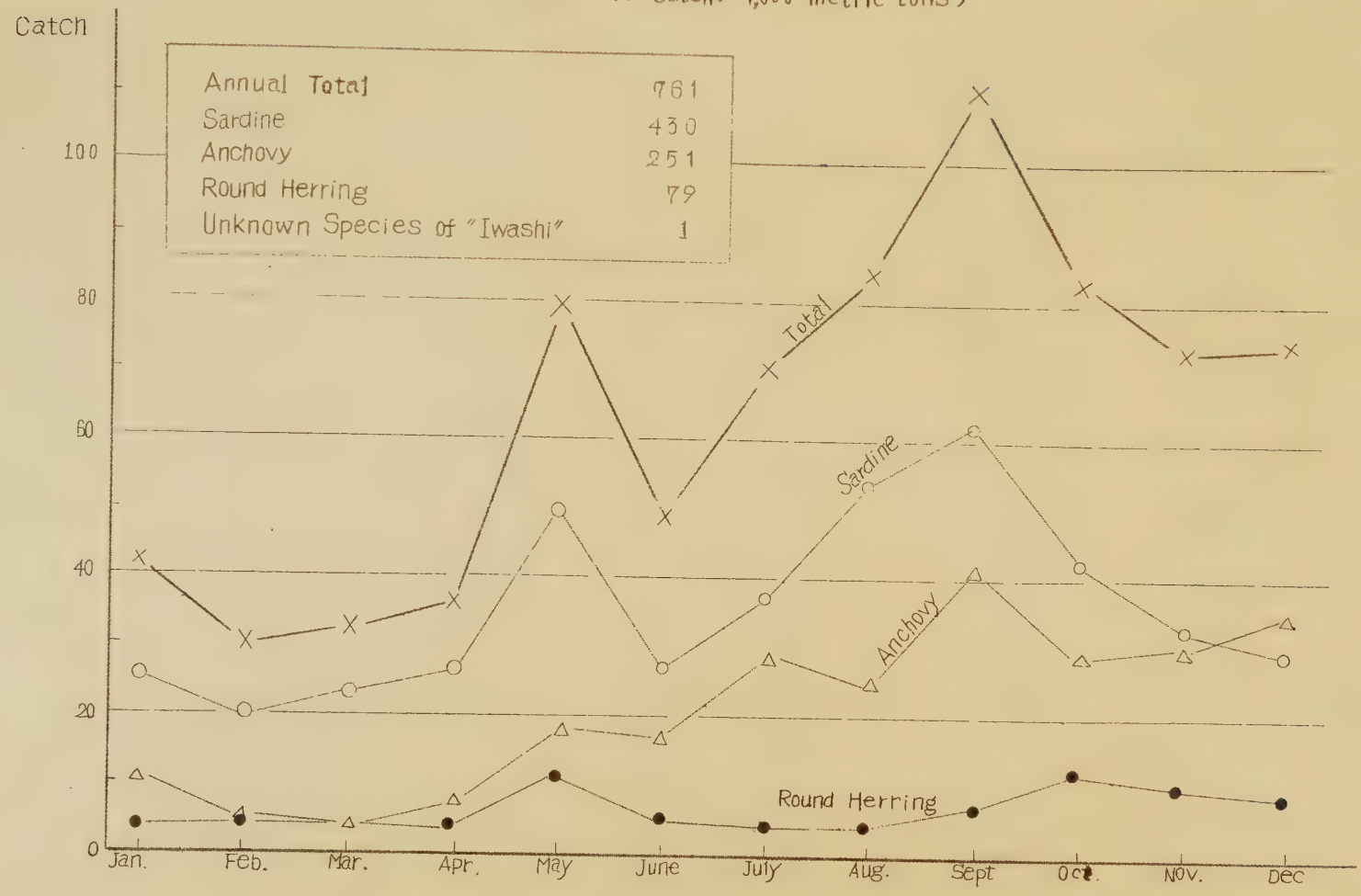


Figure 3 CATCH OF "IWASHI" BY MONTH AND SPECIES
January to December 1951

(Unit of Catch: 1,000 metric tons)



4. Fishing Gears. - Fishing gears employed in catching "iwashi" are quite numerous in regard to type, construction and size. Because, in the first place, the fish to be caught consists of three species covering every stage of the growth from the young to the adult. Secondly they inhabit in waters with intricate environments and topography characteristic to the Japanese Islands. These gears may be classified roughly into seven types:

"Maki Ami" = Round Haul, "Jibiki Ami" = Beach Seine,
"Nagashi Ami" = Drift Net, "Shiki Ami" = Lift Net,
"Funabiki Ami" = Boat Seine, "Teichi Ami" = Set Net,
and "Zatsugu" = Other Miscellaneous Gears including hand line.

As indicated on Table 1, a greater portion of the three species is caught by round haul of which catch represents 49 percent of the total. The other gears in spect of their catch come in this order; boat seine (11%), lift net (8%), drift net (8%), set net (6%), beach seine (5%), other miscellaneous gears (1%), and unknown types of gears (12%).

From the end of 1950 a technique in locating a school of the fish has made a great progress with the help of an echo sounding machine applied for that purpose. The number of round haul boats equipped with this apparatus reported to Tokai Regional Fisheries Research Laboratory was as many as 348 as of April 1951.

BIOLOGY OF SARDINE

Biological knowledges and information concerning geographical distribution and seasonal occurrence of the sardine have been obtained from the results of the fishery investigation conducted by Z. Nakai since 1936 and in more recent years by numbers of scientists in regional fisheries laboratories. Outline of these results except those which have been referred in the preceding sections will be explained here together with some other biological information of the sardine, as it is a representative species of "iwashi".

1. Spawning. - Although some of the young reach faster the maturity within a year, most of them, when survived, become the parent in two or three years after spawning. No significance is observed in numerical difference between the male and the female. The ripe eggs from the mature female whose size measures 18-19 cm. in length are enumerated 40,000 to 60,000 at most. They are spawned in the coastal waters of the Japanese Islands. The general distribution of the eggs is mapped out for a period 1937 to 1941 and for the recent years in Figures 4 and 5 respectively. Major spawning grounds are located in waters within ten miles offshore except for the sheltered bays, and particularly in the southern area of Kyushu in the former period when the fishing was more prosperous than now. The spawning center has moved further north in the recent years just as the fishing became meager. In addition, the egg population seems to have dispersed over an extensive area more than ever. The spawning season comes around February or March in the southern area, and later in May to June in the northern regions. In Figures 4 and 5, the number of the eggs per vertical haul from a depth of 150 m. are expressed on the base averaged by one-degree square of Latitude and Longitude. One of the plankton net employed has the opening of 0.28 square meter, the other the opening of 0.16 square meter. The numerical

TABLE 1. NUMBER AND SIZE OF FISHING GEAR OPERATED FOR "IWASHI", with Amount of Catch by Species January to December 1951

(Unit of Catch: 1,000 metric tons)

Kind of Gear	Number of Net Operated	Medium Size of Gear	Amount of Catch				
			Sardine	Anchovy	Round Herring	Unknown Species	Total
Round Haul	1,660	Length of float side of net: 450 m.	226	105	44	-	375
Boat Seine	2,750	Length of float rope: 54 m.	16	70	1	-	87
Lift Net	1,434	Length of one side of net: 54m.	42	17	5	-	63
Drift Net	6,963	10-20 sheets of net, 54m. long per sheet, 4.3-4.6 cm. mesh.	52	0+	7	-	59
Set Net	2,485	Diameter of bag: 72 m.	26	15	2	-	43
Beach Seine	2,780	Length of float rope: 270 m.	15	18	1	-	35
Miscellaneous Gears	-	Not applicable	3	1	1	-	5
Unknown type of Gear	-	Not applicable	47	26	19	1	94
Total			430	251	79	1	761

0+ : Catch less than 500 metric tons

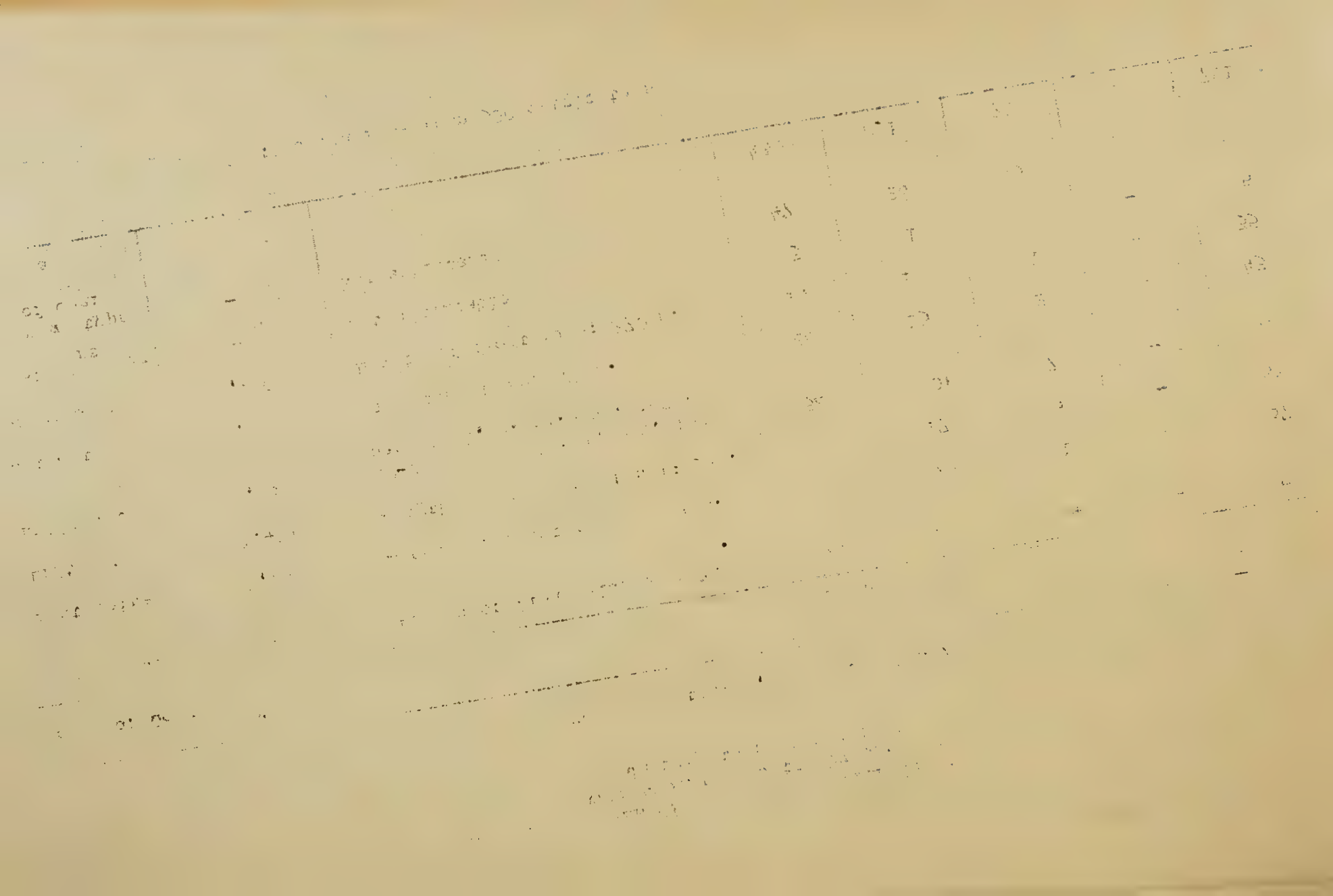


FIGURE 4 QUANTITATIVE DISTRIBUTION OF SARDINE EGGS IN MAIN SPAWNING MONTHS BY REGION, 1936 – 1941
Collected by The R. V. "MISAGO MARU"

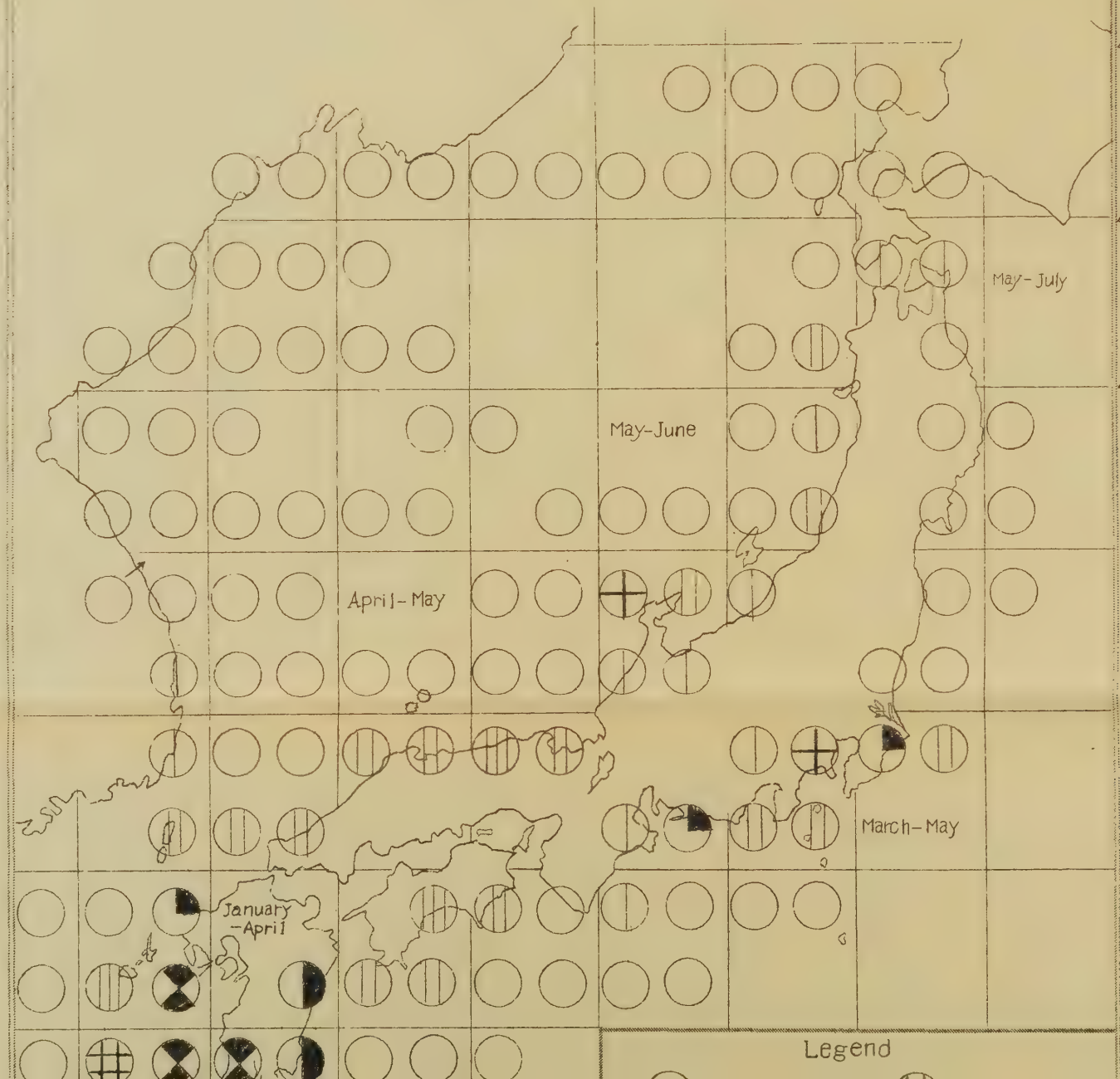
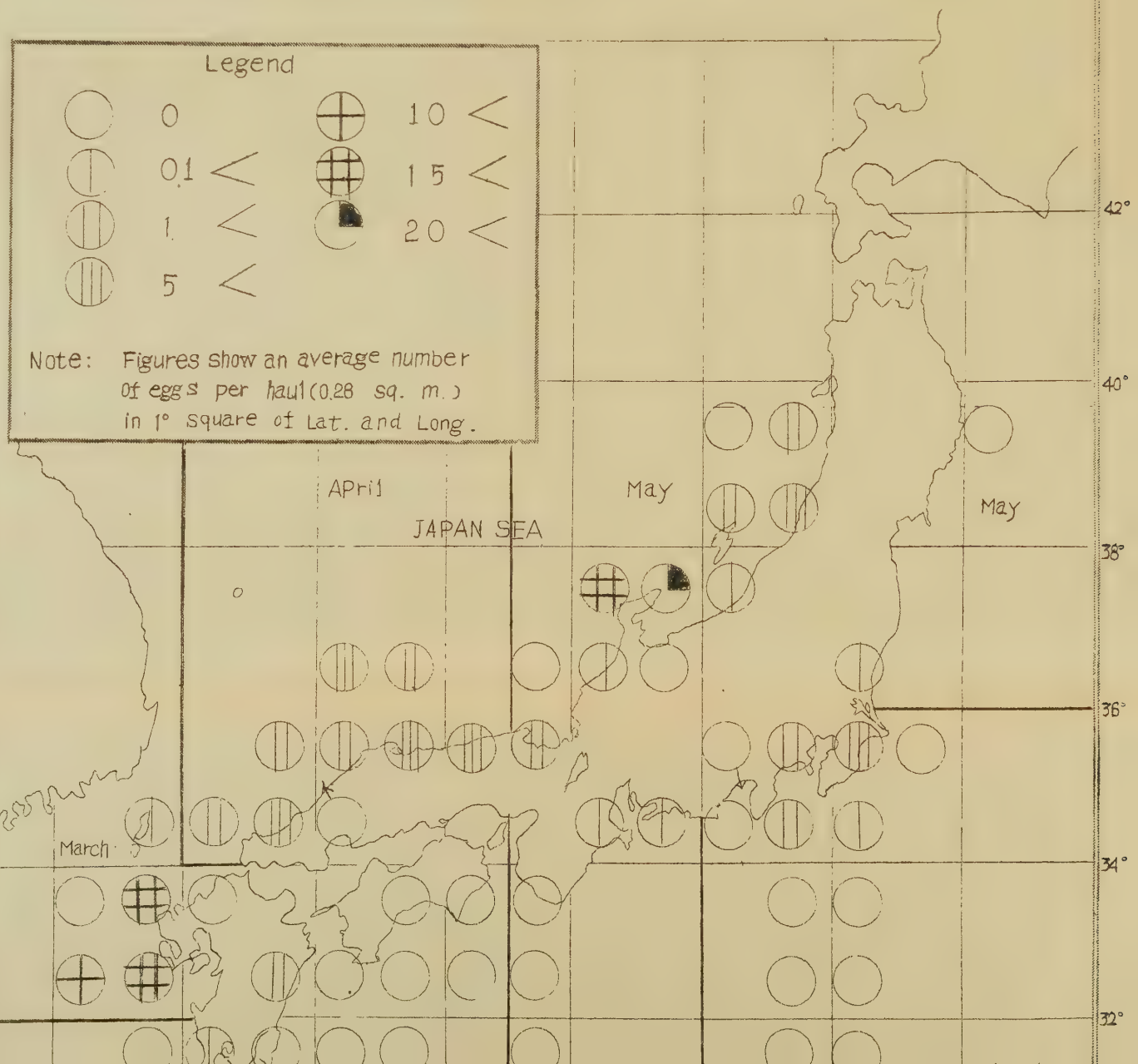


FIGURE 5 QUANTITATIVE DISTRIBUTION OF SARDINE EGGS IN MAIN SPAWNING MONTHS BY REGION IN RECENT YEARS (Japan Sea : 1950, Other Areas: 1951)



value obtained by the smaller net has been converted into that of the larger net by the ratio between the opening areas of the two nets.

When compared the two maps it is obvious that distribution of the eggs has recently undergone a remarkable change in amount as well as in localities from those of the decades ago.

It should be added that owing to transference of the spawning ground further north an average temperature of water has notably lowered to 14°-16° C. from 18°-20° C. as read in the former period when the spawning took place in the warmer water.

2. Feeding Habit. - The sardine feed on both zooplankton and phytoplankton whichever occur in its environments. For this reason food taken by the fish are almost identical with those distributed in the waters where the fish live. The principal food of sardine are the copepods, schizopods, amphipods, and diatoms. In the waters around the spawning ground the fish would evidently feed on its own larvae and eggs as very often found from the stomach of the sardine caught there.

3. Race and Migration. - Research on the race and migration has been carried on by investigating various subjects such as; geographical and seasonal distribution of the eggs, larvae, young; morphometric characters of the fish, age, and the catch; tagging experiment; ecological relationship between the fish and its environments including the currents, distribution of water temperature, and plankton.

On the basis of the results obtained so far from these investigations it may be reasonable to assume that the sardine in the Japanese waters belong to a single race. Generally speaking, the principal schools of the fish take the course of feeding migration in the spring from the southern waters to north. Then in the autumn and winter they come back to the south. In most cases of the young in the Pacific coast of Japan, they are assumed to migrate from north to the Japan Sea, passing through the Tsugaru Straits in fall and winter when they become two to three years old. Some shoals, however, would evidently remain in a certain area of the sea without taking that long course of the migration.

It is assumed that not only the remaining shoals have come greater in proportion, but also the migratory shoals spend more time in their trip than they used to do. This was particularly the case with the adverse fishing situation of last decade. As mentioned in the preceding section, the principal spawning ground changed from the previous location to the present area, where direction of the current is entirely different from that of the previous ground. This seems to have made the eggs and larvae drift in other waters than before. As a result, nearly all of them ceased to be supplied in the Pacific side of the waters, a fact which caused in turn a remarkable rotation of the fishing grounds. With such a serious influence exerted upon, the stock of the sardine is, to all appearance, in a position where the healthy recovery to the abundance as it ever had cannot be expected in the near future.

4. Age Composition, Apparent Survival Rate and Growth Rate. - Total number of the catch in 1951 is deduced to be 30,000,000,000 individuals. The age composition of the catch is tabulated below:

Age	Year Class	%	Age	Year Class	%
0	1951	94.21	V	1946	0.20
I	1950	3.17	VI	1945	0.16
II	1949	1.33	VII	1944	0.03
III	1948	0.63	VIII	1943	0.01
IV	1947	0.26			

An outnumbered catch of the young under one year.

The age determination has been derived from composition of the body length on the basis of the scale reading. It must be admitted, however, that the age of the V age fish and the fish older than it is found difficult to secure accuracy, and that the result thus obtained is not so reliable as the case of the younger. A research is under way in this regard, however. Calculation on the apparent survival rate of the fish in 0-IV age gives forth the results: 0-I: 0.034, I-II: 0.419, II-III: 0.465, and III-IV: 0.419. The survival rate of the fish after I age nearly comes in the middle of the values for the survival rate of California Sardine obtained by Ralph P. Silliman (1943) which are 0.6 for the fish of 1925-33 classes and 0.2 for 1937-42 classes However, much attention has been paid for a proportional greatness of the 0 age fish in age composition with the pertinent research in progress.

In regard to the growth rate, considerable differences are observed among the yound depending on the localities, a factor which counts for but little in case of the II age fish and the olders. The body length of the sardine in various age groups was measured at the end of the year for a recent period. The result shows approximately:

the fish hatched in that year measures . . 8-16 cm. in length
at the end of the second year . . . . . 16-19 cm. "
at the end of the third year . . . . . 19-22 cm. "

The growth rate of the fish older than these are not so perceptible with few exception in which a maximum length is recorded 25 cm.

In view of a fact, however, that the growth rate up to 1941 was not so great as stated above, negative correlation between the growth and the magnitude of the stock has been manifested.

RESEARCH PROGRAM

1. Purpose. - Scientific research on the resources of "iwashi" will inevitably concern a great deal of problems such as:

whether or not fishing is being operated at an excessive intensity in what case overfishing, if any, will be resulted in future; if overfishing is apparent or feared to come, what amount is supposed to be an optimum catch; what measures should be taken for the management of fisheries; whether influence from the environments is a major cause in fluctuating the stock; and if so, under what environments it occurs; in what processes and how much they affect the stock to change; whether such adversive influence can ever be prevented in some way or others by human efforts.

To solve these questions and to predict fluctuation of the stock and migratory conditions with a maximum accuracy in regard to seasons and localities are the aultimate purpose of the research.

A step next to the goal related above is to find out the natural mortality, fishing mortality, growth rate, and the recruitment. A preliminary study needed for this step includes; (1) statistical analysis of age composition of the catch; (2) investigation on hydrographical and meteorological conditions and biological environments such as food and predators which may affect the natural mortality, growth rate and the recruitment.

2. Methods. - In order to realize these requirements the range and subject matter of the research work covers:

> statistical compilation of the catch and fishing effort; biological studies on life history, race, distribution, migration, age, growth, body length, body weight, vertebral counts, and other morphological elements, sex ratio, maturity of gonads, number of ova, spawning localities, spawning season, amount of the eggs spawned, hatching rate, survival rate of the eggs and larvae, food plankton, and predatory animals; hydrographical and meteorological studies on air temperature, rainfall, temperature, salinity, currents, and nutriments of the sea.

Practical methods applied for these objects are summarized below;

a. Statistical survey of the catch. - The catch and fishing efforts, by species, type of gear, and month, are being collected from landing ports and fishing villages all over the country by means of either census or sampling system in accordance with local situations. In addition the daily catch is reported from round haul boats sampled out of many.

b. Morphometric survey and age determination. - The specimens are systematicaly sampled from various localities for morphometric survey of which items are:

> body length, body weight, analysis of stomach contents, sex ratio, weight of gonads, diameter of ova, and vertebral counts. Age of the sampled fish is determined by scale reading. Another series of accessory items which are requested to report in relation with this sampling include: the catch by species from which to sample specimens, sampling fraction of number of the specimens to be used for age determination, type of gear, locality of the fishing grounds, total catch at the landing place, number of fishing boats operated, and so forth.

c. Investigation for spawning, plankton and hydrographical conditions. - Research vessels (numbered 31 as of 1950) has been employed, either in a period covering the spawning season or every month, for the field investigation at 370 stations (designed as of 1950) in the coastal areas all around the country. All the cruise are carried out once in every month under the investigation of which items include:

vertical haul by a plankton net; temperature, salinity, color and transparency of the sea; study of currents by drift bottles; meteorological observations as field works; quantitative analysis of the eggs and larvae of "iwashi", and other planktonic organisms as laboratory works.

d. Investigation on fishing ground. - The research vessels are employed in important fishing grounds and the adjacent waters to investigate hydrographical and meteorological conditions such as:

location of the shoals, fishing situations, quantitative distribution of plankton and predators; water temperature, currents, transparency, color, salinity, and nutrient salts of the sea.

e. Tagging experiment. - Numbers of the fish are released with a celluloid tag fastened on the body. Recaptured fish are reported to the research laboratories assigned to the experiment. In addition, the tagging mortality of the fish is studied by releasing the tagged fish in a live car. Attempts should be made at improvement of tagging techniques.

f. Development of scientific apparatus and methods for preliminary study and investigation. - Scientific methods and apparatus will be introduced or improved for field collection, oceanographical observations, and laboratory treatment in regard to morphological, ecological, and physiological researches on sardine, anchovy, round herring, and related life.

3. Organization. - A conference is to be held twice a year by the personnel in charge of the investigation. They will represent six fisheries research laboratories of Tokai, Nankai, Seikai, Japan Sea, Hokkaido, and Inland Sea Regions. Fisheries Agency and Statistical Division of Ministry of Agriculture and Forestry will participate in the conference, which discusses the investigation program and methods for the year.

Statistical survey of the landings is assigned to Statistics Division with supplimental checking by the regional laboratories. The regional laboratories are responsible for conducting investigation on morphometric items, age and spawning date in which 33 prefectural experimental stations will cooperate. Fishing ground survey and tagging experiment are as a rule taken up by the regional laboratories.

N O T E

This paper has been prepared by the request of Fisheries Agency for submitting it before the Fourth Indo-Pacific Fisheries Conference to be held in Manila in October 1952 in which Dr. M. Fujinaga, chief of Research and Investigation Department, Fisheries Agency, and Dr. K. Kuronuma, director of Fresh Water Fisheries Research Laboratory will represent the Japanese Government. For this reason the author does not attempt to describe anything more than a general introduction to the present status of "iwashi" fisheries and reseach program related to them. A scientific report which will include factors causing adverse fishing as happened in the recent decade

and other essential results from research is expected to be prepared in other opportunities. For assistance in preparation of this information, acknowledgment is made to the following persons: Messrs. M. Ishida, S. Usami, S. Hattori, K. Honjo, and S. Hayashi, staff of Sardine Resources Division, Tokai Regional Fisheries Research Laboratory.

October 1952

Zinziro Nakai